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PRESENTATION TO THE BEARP PANEL: Effects of Vessel Traffic on Whales in Lancaster Sound

INTRODUCTION

The possible growth in year-round shipping activity through the Northwest Passage in support of petroleum and mining development has generated a considerable amount of concern. This concern focuses on two broad issues:

Issue 1 The effect of ship-generated sound on marine mammal communication, behaviour and distribution.

Issue 2 The physical impact of ice-breaking activities on the ice regime, and thereby the effect on marine mammal distribution and hunter success and safety.

The following summarizes DIAND studies which were designed to address the first issue. However, during the course of these programs observations were also made which are relevant to the second issue.

BACKGROUND

Examples exist of the apparent compatability of ships and marine mammals in busy shipping areas such as Tokyo Harbour and San Francisco Bay. There are also numerous reports of the "friendly" approach of grey whales to ships on the coast of California, and of porpoises riding the bow wave of fishing boats. In Canada examples include the Churchill and St. Lawrence Rivers, where beluga whales and shipping have co-existed for many years; although the historical status of these whale populations is not well documented. In addition, impact predictions, based on ship sound production and the measured hearing thresholds of beluga whales, were provided at NEB hearings on the Arctic Pilot Project (APP). These predictions suggested that beluga and narwhal would be unable to detect ship noise beyond a distance of 5-10 km. Studies in the western arctic, funded largely by the proponents of the Beaufort Sea Development Proposal and the U.S. Government, indicate that beluga do react to ship generated disturbance, but these animals generally respond only to quickly changing and intense ship noise when a vessel is moving towards them.

In spite of the observations that have been made, the NEB hearings on the APP emphasized that little direct knowledge exists about sound attenuation in arctic waters and the response of bowhead, beluga, narwhal and other marine mammals to icebreaking ships. Predictions were, by necessity, based largely on simulation models of ship-noise production and on limited anecdotal references to whale behaviour.

Regarding the issue of arctic shipping interfering with native hunting, information is limited. The proponents have conducted trials, primarily in the Beaufort Sea, of ice formation and consolidation in the track of ice-breaking ships. Trial results suggest that a ship track will present little danger to hunters or to the migration of whales. Still, concern remains as to the applicability of these studies to the Lancaster Sound area, particularly during spring when winds and currents exert strong forces on the fast ice.

DIAND recognizes that environmental debate concerning arctic shipping is due in part to a lack of understanding about marine mammal behaviour, and to inadequate data on sound physics in arctic waters. Therefore, when the community of Arctic Bay expressed concern about the effects of the early arrival of the icebreaking ore carrier MV Arctic in June 1982, and the possible effects of this event on the narwhal hunt in Admiralty Inlet, DIAND initiated a preliminary study. That study was followed in 1983 by a more comprehensive program.

1982 STUDY

DIAND, with the support of Canarctic Shipping, APP, DOE and GNWT mounted a field study at the Admiralty Inlet ice edge with the support of Inuit from Arctic Bay and scientists associated with LGL Ltd. The study had two related field components:

(a) acoustic measurements using hydrophones suspended below the ice for recording ambient noise, whale vocalizations and ship noise;

(b) changes in whale behaviour and distribution in relation to the MV Arctic.

Results (1982)

Although limited to less than one week, the study offered several interesting observations.

(a) Acoustic measurements: Ship noise recorded from underwater hydrophones was audible to the observers at a distance of 45 km. On subsequent analysis of the hydrophone recordings ship noise was detectable at 105 km. (received sound level of 64 dB// 1 uPa for a tone at a frequency of 205 Hz.). As expected, low frequency sound (i.e. less 500 Hz) from the MV Arctic was the most clearly audible. It was interesting to note that when the ship was in forward mode the strongest tones (frequencies of 53 and 205 Hz with estimated source levels of 171 dB// 1 uPa-m) were generated by machinery noise, such as the cylinder firing of the diesel engines, and not by propeller cavitation. During icebrreaking the noise produced when going in reverse was substantially greater (≈5dB) than noise associated with the forward mode. The greatest noise production occurred during the brief (5 s) transition from reverse to forward thrust.

Whales emitted an extensive range of vocalizations. Subsequent analysis allowed the identification of at least 77 distinct odontocete whale call types as well as "click series". Certain calls were confined to the period of ship proximity at which time whale vocalizations were dominated by high frequency complex calls and "clicking" calls at an increased repetition rate.

(b) Whale behaviour: The approach of the ship appeared to affect each species in different ways. Beluga responded with apparent avoidance movements while the ship was 35-40 km away. They swam along the ice edge away from the ship in a manner described as very rapid, atypical and lacking pod synchrony. Narwhal, in contrast, remained quiet and moved up against the ice where they lay motionless. The rapid movement observed with beluga did not occur with

narwhal although the narwhal did move away from the point of ship entry into the ice. Both species returned to the ice edge in similar numbers within 30 to 40 h after the arrival of the ship.

(c) Study Limitations: The major limitations to this preliminary study were -

(a) the short project duration and the limited amount of predisturbance behavioural observations;

(b) the necessity of restricting observations to only one trial exposure, thereby preventing investigation of the ability of whales to adapt or acclimate to repeated ship disturbance; and

(c) unstable ice conditions, and the inadequate aerial surveys.

The 1982 study did, however, provide some preliminary indications and assisted in the design of the more comprehensive study conducted in 1983.

1983 STUDY

This study, conducted in June and July, took advantage of the presence in the eastern arctic of the MV Arctic and the Canadian Coast Guard icebreaker John A. MacDonald. DIAND acted as project coordinator for a group of sponsors that included DIAND, Canadian Coast Guard, APP, Canarctic Shipping, DOME, Gulf, CMO and the Danish Government. Once again, LGL Ltd. was the primary consultant with Arctic Bay residents providing logistical and technical support.

The study consisted of 3 components:

(a) Noise trials of the John A. MacDonald were conducted at the Department of National Defence sound range in Halifax harbour. The tests determined the noise source levels and characteristics of the icebreaker in ice-free waters. The data are now being analyzed by the Defence Research Establishment for presentation to the Canadian Coast Guard.

(b) A ship-based study of underwater sound physics was conducted with the John A. MacDonald. This study measured ship-noise levels and characteristics under various conditions of propeller loading, and measured sound transmission loss in different water depths and ice conditions, while the ship was in transit from Dartmouth to Nanisivik. Seven people aboard the John A. MacDonald, including two acousticians from Denmark, participated in this aspect of the study. Tests were conducted in 7/10 ice in Baffin Bay, S.W. of Thule, Greenland, and again in 2-3 m thick fast ice in Lancaster Sound. Sound was recorded via hydrophone arrays at distances of 0.5 km to 33 km from the ship.

(c) An expanded and more comprehensive version of the 1982 ice-edge study was undertaken to investigate whale behaviour, vocalizations and the reaction to ship noise. This study included 18 aerial surveys to document whale distribution and pod composition. These were supplemented by near continuous behavioural monitoring from ice-edge stations by biologists and hunters from Arctic Bay. Acoustical and behavioural data were collected throughout a 3-week period.

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Preliminary Results (1983)

The detailed analysis of the voluminous 1983 data and the preparation of a final report on both the 1982 and 1983 work are yet to be initiated. It should be stressed that until analysis is completed of sound recordings, aerial survey data, photographs and satellite imagery, these conclusions are tentative.

(a) Acoustic measurements: Excellent recordings of whale vocalizations and echolocation calls were made on normal and high frequency (<120 kH2) recorders. Unique opportunities allowed the recording of individual species calls at very close range (i.e. a few meters). Upon analysis of the tapes it should be possible to document much of the lexicon of narwhal and beluga, and to determine the sound source levels for both species.

The noise of the breaking of ice during ship movement was undetectable in relation to the noise generated by machinery and propellor cavitation. As in 1982, sound production by the ship was highest in icebreaking mode when the ships were forced to continually shift from reverse to forward speed and ram the ice under full power. Complete analysis of ship recordings will provide hard data on noise attenuation for evaluating computer model predictions.

(b) Behaviour of marine mammals: The MV Arctic re-started its engines the morning of June 26th at a position approximately 12 km into the fast ice of Lancaster Sound after hours of silence. Immediately both narwhal and beluga were observed swimming close to and under the ice edge towards Cape Hay and away from the noise source. Movement of belugas in particular was very fast and concentrated (e.g. 225+) animals passed the ice edge observers in 9 minutes). The observation seems to confirm the avoidance reaction to ship noise reported in the previous year's study. Beluga did, however, return to the area of ship entry within approximately 24 hours. Until further analysis of aerial survey data is completed, it is only possible to say that this behaviour was roughly comparable to the 1982 observations wherein beluga had returned in similar numbers within 30 to 40 hours of the arrival of the ship. At least some narwhals remained near the ice edge within a few kilometers of the ship entry, and narwhal again appeared to react less dramatically to the presence of the ships.

Although somewhat incidental to the whale observations, it was interesting to note that numerous ringed seals and some bearded seals were observed swimming for long periods of time in the turbulence directly behind (less than 50 m) the John A. MacDonald while the ship was in icebreaking mode in Lancaster Sound.

(c) Ice integrity and ship tracks: While the thrust of the study was to record ship and whale sounds, and to document behavioural responses, opportunistics observations were made on changes in ice integrity associated with ship tracks. Future analysis of satellite imagery and exact ship positioning will provide further insight into the changing ice patterns associated with the activities of the MV Arctic and John A. MacDonald.

The ice conditions were particularly severe in 1983 as manifested by the location of the ice edge across the eastern boundary of Lancaster Sound in late June. Because of these conditions the MV Arctic required the assistance of the John A. MacDonald from the ice edge to Nanisivik mines. Ship progress was very slow requiring about 14 days of icebreaking to travel through approximately 180 km of fast-ice. In June 1982, the unaccompanied MV Arctic required only 2 days to travel 60 km of ice through Admiralty Inlet.

The John A. MacDonald arrived at the ice edge 2 days after the ore carrier and attempted to cut diagonally through the ice to reach the MV Arctic. It proceeded less than one km into the ice before reversing to re-enter in the track already started by the MV Arctic. Following this, a large wedge of ice measuring several km^2 broke from the main body of ice and drifted west effectively creating a new ice edge. Margins appeared to be formed by the MV Arctic-John A. MacDonald ship track to the south and the aborted John A. MacDonald track to the north.

It was possible to walk across the ice rubble behind the ships immediately after passage. Crossing by snowmobile was more difficult but could be accomplished with caution. The ice rubble did not re-freeze but remained composed of small, loose pieces. Winds and currents affected the degree of ice consolidation. For several days no whales were observed using the densely packed ship track confirming the observations of 1982.

On July 2, eight days after the arrival of the ore carrier, and 6 days after the arrival of the John A. MacDonald, ice north of the ship track began to move, sheering against the ship track in places and creating open water in others. Several large cracks, extending for many km, opened from the ship track north and west to the ice edge. At this time whales began to migrate west through the ship track and cracks to a position northeast of Cape Charles York. The ship track also became more difficult to cross by snowmobile due to the shifting width of the track. On July 8 the ice again shifted enough to create open water in the ship track and allow whales to travel further west.

Numerous hunters from Arctic Bay and several from Pond Inlet were present at the ice edge and at ice cracks further west where they were particularly successful at taking narwhal. These cracks were probably induced by the ship track.

CONCLUSION

Thorough analysis of the physical and biological data collected over the last two years will go a long way towards defining the underwater noise issue. The Department will continue to cooperate with other government agencies, industry and interest groups in future programs that will lead to the resolution of any environmental problems associated with arctic marine transportation.

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Education

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1970-1974	U. of Guelph, Guelph, Ontario. Bachelor Science Honours Program: Wildlife Biology
1965-1970	Niagara Falls, C.V.I., Niagara Falls, Ontario. Grade 13

Experience

1982-	Offshore Environment, DIAND, Ottawa Biology, impact assessment, project assessment
1980-82	Contracts, Canadian and Norwegian Govts., Ottawa, Oslo Norway Computer model simulations of polar bear and seal thermoregulation and energy requirements. Thermal properties of fur and blubber.
1981	Research, Magdalen Islands sea ice Thermoregulation in harp seals. Insulation and hormonal control of thermogenesis
1978-1980	Polar Bear Project, Churchill, Manitoba Laboratory and field research on the bioenergetics of polar, grizzly and black bears. Thermal and metabolic effects of oil on polar bears
1979	Northern Studies Centre, Churchill, Manitoba
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